Yu Yuan. An Exploration of User Engagement With a Search Assistance Tool in Different Positions on a SERP. A Master's Paper for the M.S. in I.S degree. April, 2019. 60 pages. Advisor: Robert Capra

This study aimed to explore the difference in user engagement with a search assistance tool in different positions on a SERP. A usability study with eye-tracker was conducted in a lab environment. Overall, there were 12 subjects participated in this study, each of them was asked to perform two tasks on a search system with a search assistance tool placed in two positions. Qualitative data collected from retrospective interview and quantitative data gathered from questionnaires, eye-tracking system and custom log system were analyzed to investigate the position effect. The results in this study showed that the search assistance tool placed in the middle is easier to get noticed while people are more likely to pay attention to it and use it when the search assistance tool is placed on the right side of the page. Also, the source authority and the information foraging theories like Camouflage Links, Banner Blindness have impacts on the use of the search assistance tool.

Headings:

Search Assistance Tool

Information Search Behavior

Eye-tracking

User Study

AN EXPLORATION OF USER ENGAGEMENT WITH A SEARCH ASSISTANCE TOOL IN DIFFERENT POSITIONS ON A SERP.

by
Yu Yuan

A Master's paper submitted to the faculty
of the School of Information and Library Science
of the University of North Carolina at Chapel Hill
in partial fulfillment of the requirements
for the degree of Master of Science in
Information Science.

Chapel Hill, North Carolina

April 2019

Approved by

_____

Robert Capra

Table of Contents

1. Introduction

Going back to 1996, Sergey Brin and Larry Page, two Stanford students, launched Backrub as a project, which laying the foundations for Search Engine Result Page (SERP). Till now, SERP have become more diverse and dynamic over the years, not only the original results would be provided to users, various kinds of assistances, like pictures, videos, knowledge panels, placed in different positions has also been introduced to aid the searching. With the advent of the rich text and assistances, how does the searchers nowadays interact with the SERP and the search assistance in different positions became the focus of this study. To figure out the answer, this research explored the user information-seeking behaviors on the SERP with a search assistance tool in different layouts.

Numerous of the works and techniques in this area have explored the users' behavior on SERP when they perform easy (navigational) information search tasks. Meanwhile, several studies have shown the differentiation of human seeking behaviors when they are asked to deal with tasks at various levels of difficulties. To give more support on those complex (analytical/evaluative) tasks, various interactive tools are investigated, among which different information, such as prior user search trails, concepts, opinions, are embedded into the SERP.

Basically, there are two types of information assistance formats that prior studies have been working on – verticals among the original results & entity card placed on the

top-right of the page; both of them has shown their impacts independently. Generally, verticals on SERP provide objective information related to the search terms, such as image, video, shopping information, news, etc. (Arguello & Capra, 2014); while in the entity card, previous studies tried to provide either objective or subjective (opinion, user trails, etc.) even both (Navalpakkam et al., 2013; Bota et al., 2016).

In this study, we are interested in whether user engagement on SERP would be affected by the position of a search assistance tool containing both objective and subjective information. Two positions were evaluated in this study: 1) the assistance tool was placed among the main search results -- under the first 2 results, and 2) the assistance tool placed to the right of the main search results. User engagements on SERP include both their interaction with the assistance tool and with the results on SERP. In addition, an eye-tracking device and its system was introduced in this study to interpret users' information gathering pattern as well as the areas of most interest on the page.

2. Literature Review

2.1. User Engagement

In line with the emerging of alternative choices on the Internet: dozens of general web search engines, numerous social media platform, etc., there is an impetus to move beyond caring about the system's usability. It's in need to involve the user engagement into the product development process. What's user engagement? Its definition has been adapting for decades; during the time, Laurel defined the engagement as "the state of mind that we must attain in order to enjoy a representation of an action" (2013, p.139), while from the perspective of how system works, it relates to the capability of "encourage interaction" (Bannon, 2005, p.50), and "excite, motivate and enhance the user experience" (Albers & Mazur, 2003, p.86). Considering some important factors in the real industry, e.g. the user loyalty, user engagement should be examined in different aspects, as a result, Lalmas et al. (2015, p.3) gave their definition to distinguish it in three dimensions: it "is the emotional, cognitive, and behavioral experience of a user with a technological resource that exists, at any point in time and over time".

2.2. Measuring User Engagement

As stated earlier, user engagement is a multifaceted phenomenon which brings about a quantity of approaches to measure it. Physiological measurement is one way to access it via the body functions, in which eye-tracking and mouse event are two methods

commonly adopted in some search studies. They help to generate large amount of objective data, such as clicking event, eye gaze data, etc., to provide evidence on users' attentional responses even though users may not be aware of (Lalmas et al., 2015). In another words, the data collected from these methods will not depend on users recall about their experience, which is inadequate for the researchers to learn the insights behind.

Self-reports, aiming to encourage people to share their perceptions, might be an alternative to make up the loss; which including interviews, questionnaires, think-aloud, stimulated recall, etc. The benefits of applying this method include gauging how engaged were the user with the system, protecting the user from being identified, as well as keeping the scale of the sampling (Fulmer & Frijters, 2009). Use Engagement Scale (UES) is the latest questionnaire designed to measure the engagement using 31 items in six sub-scales (O'Brien & Toms, 2010), which has been widely used with different types of system, such as e-shopping platform (O'Brien, 2010) and Facebook (Banhawi & Ali, 2011). And in 2018, O'Brien et al. (2018) developed a new short form of the UES within 4 sub-scales as well as a guidance of adopting this into the study. Other self-report methods, like interview and think-aloud, give rise to learn the participants insight and how they interpret and experience with the system.

2.3. Search Engine Result Page

To response to the human query, the web search engine provides a page with a list of results in which each item on the list includes the linked web page title with URL, a brief abstract of the page content. That is the Search Engine Result Page (SERP). In

Chowdhury et al. (2014)'s study, they found that the uncertainty during the information search and retrieval (IS&R) process is not only caused by a knowledge gap between users mind and the system language, it exists across different stages of IS&R process and triggered by a number of information-seeking activities. Learned from this uncertainty model, in order to minimize the negative impact on the uncertainty in the search process, researchers use the collective qualitative data to interpret even predict human information behaviors and launch several search assistances on the SERP.

2.4. Search Assistance on SERP

Various kinds of search assistance are designed to facilitate the users search experience in different aspects of the search process (Capra et al. 2015), for example, Google SERP provided several types of display features: 1) Featured snippets might be shown above the original results when users ask a question in Google Search, this contains a summary of the answer which extracted from a webpage, followed with a link to the page, the page title, and URL (Google, 2019); several kinds of featured content might appear in the snippets—numbered, bullet points, and paragraph. 2) Knowledge panels, information boxes displayed in a rich outcome with images, text, and links which are always integrated from multiple webpages, and it is appeared on the right side of the SERP when users search for entities (Google, 2019). 3) Verticals are usually placed in the middle of the search results and displayed as a carousel (Melucci & Baeza-Yates, 2011). Depending on what users search, it provides tailored media to rich the page; common type of medias is video, image, news.

In Arguello & Capra's (2014) study, image vertical has shown stronger spill-over effects and the variety of positions will not produce statistical significance on it. While by

using the eye-tracking technique, Bota et al. (2016) has shown that the Entity Card's influence on the user search behavior; among which diverse cards (with pictures) present on the SERP generating less workload on users than non-diverse card (without pictures). And in this study, pure textual assistance will be provided to study its effect on users' attention and engagement.

2.5. Understand Search Behaviors using Eye-tracking

Eye-tracking technique has been used commonly so as to acquire detailed data to study users' eye-gaze while they're performing search tasks (Guan & Cutrell, 2007; Lorigo et al., 2006; Lagun et al., 2011; Rodden & Fu, 2007, 2008; Dumais et al., 2013). From their work, the variation of user visual attention has been explored. Two studies (Guan & Cutrell, 2007; Lorigo et al., 2006) found the effect of task complexity was reflected on the variation of time and effort the participants spent on navigational tasks and informational tasks—people spent more time on the informational search and were less likely to issue a new query. By investigating the users' reading pattern on SERP, Thomas et al. (2013) found that users worked their way down the results list more quickly, and also to a greater depth, on average position when they are performing more complex tasks. In addition, in Dumais et al. (2013)'s study, they found that, on the SERP which consist of original results, ads and related searches, users would pay more attention on the middle part rather than other regions.

A large body of prior works has used eye-tracking techniques to understand how users examine the search results on a SERP. It has been stated that the positions and relevance of results affect the searchers' examination of the SERP (Pan et al., 2007; Rose & Levinson, 2004). Two studies (Aula, A. et al., 2005; Granka, L. A. et al., 2004) they

divided the searchers into two types-- exhaustive and economic users. Exhaustive searchers examine the SERP thoroughly, looking back and forth through the result list several times before choosing a result link to click; while the economic users look over the result from top to bottom once and select the very first result link they examined. In addition, prior work has studied aggregated search results pages that incorporate different “vertical” elements, Liu et al. (2015) found that users’ examination on original results may be "cut off" by the placement of vertical results position.

3. Methodology

3.1. Search System

The search system used in this study is the InfoBox search system developed by the Interactive Information Systems Lab led by Dr. Robert Capra. It allows participants to construct queries, navigate to different pages from the search result page, as well as provides information related to the search. The initial system assisted the user search with four types of information—Facts, Opinions, Concepts, and Insights, and represented them by placing an information box on the right side of the search result page with a tab bar. In this study, in order to exploring user engagement with the search system and the search assistance tool in different positions, two layouts of search interfaces were developed based on the initial system: 1) the search assistance tool is placed among the main search results—under first two results, and 2) the search assistance tool is placed to the right of the main search results. Except the different positions of search assistance tool, the content and the structure of these two interfaces are identical: the task description is shown above the search box, and the search results is listed below the query. For each, it contains the page title in blue followed by URL in green and a description about that page. The pagination is placed at the bottom of the page (Appendix 7).

3.1.1 Search Assistance Tool—InfoBox

In the search assistance tool, we provide two types of information—Fact and Opinion—placed in separate boxes which contain 10 related information sources

represented by the subset of the web page and the URL. The word in the subset matched with the user query will be shown in bold, only the top two items will be displayed as default and once the user clicks the “Show More”, the rest will be provided.

3.1.2 Search Environment

We use Firefox (version 45.0.9) to support the search system and the Tobii Eye-tracking Extension. In addition, there are four buttons on the bookmark tab menu to support the participants to complete the tasks: 1) bookmark this page, 2) show bookmarks, 3) re-open search page, 4) done with the task. During the task, the participants were asked to use the “Bookmark this page” button to collect useful information answering to the task, and if they wanted to see all the bookmarked pages, clicking the “Show bookmarks” button would display a pop-up window listed the current set of bookmarks. And the “Re-open the search page” would help the participants to go back to the search result page with their query.

3.2 Usability Study

In a lab environment, a usability test with an eye-tracker was conducted with 6 pilots and 12 participants in room 012 at Manning Hall. Each participant was asked to complete two tasks by using a search system to find and bookmark webpages that were useful in constructing an answer for the task. While they were working on the task, we used a Tobii X2-60 eye-tracking system to keep track of where they looking on the computer screen. We also recorded the screen activity and audio of the session. We used an entry questionnaire to collect basic demographic information of the participants. Before and after each task, they were directed to a brief questionnaire to answer questions

related to the task. After the tasks, we administered a retrospective video recall interview to learn insights about their actions.

3.2.1 Experiment Design

The study was progressed as the following sequence. Participants were welcomed by the moderator and explained the system that would guide them through the experiment. They were provided a written consent form (Appendix 2) to sign, as well as a second hard-copy version which was offered to them to take with them. After assigned the participants with specific ID to record, they were given a brief introduction of the study procedure as well as the instruction of the search system with buttons. Then the moderator would help the participants to calibrate the eye-tracking equipment and began recording the participant's screen. After entering their participant ID, the participants were asked to start the study with an entry questionnaire (Appendix 3) asking about basic demographic information and the search self-efficacy, after which the search system would guide them through the rest of the experiment procedure.

Participants were asked to use a live search system to find web pages that would be useful in constructing a response for the task. Each participant worked on the same two tasks by using the system with search assistance tool in two positions (horizontal and vertical) correspondingly. For each task, it followed the same procedure:

1. Pre-task. Participants read a task description carefully and completed a pre-task questionnaire (Appendix 4) which to assess their prior knowledge and the prejudgment of the topic via 3 aspects: 1) their personal interest of the topic, 2) their prior knowledge, 3) the topic difficulty, and 4) their perception about the "a priori determinability" of the task.

2. Perform task. Participants were then directed to the initial search interface and performed the task. They were instructed to search naturally by constructing queries, navigating to different pages, and collecting useful information for the tasks in order to complete the task. During the exploration, participants were asked to bookmark useful information as they found it. Participants made their own decision about when to complete the task based upon whether they had found enough information to satisfy the task.

3. Post-task. Participants were asked to fill out a 5-point scale post-task questionnaire (Appendix 5) about the system quality and their engagement with the tasks. The questions were adapted from the User Engagement Scale (UES)-Short Form (O'Brien et al. ,2018). In this questionnaire, we measured user engagement by asking nine questions related to three sub-scales, focused attention (FA), perceived usability (PU), and Reward Factor (RW).

After the participant had completed the tasks, the moderator played back portions of the recordings (computer screen and eye movements) around the first use of the InfoBox for each task and asked questions about: (a) the overall system support based on the content it provided, (b) their experiences using the two types of InfoBox, (c) any benefits gained from using the InfoBox search assistance tool, and (d) how they focused their attention (or not) on the different types of information presented in the InfoBox search assistance tool. Participants were offered a $15 incentive and asked to sign a receipt acknowledging the payment.

3.2.2 Task Selection and Description

Fact-finding Task—HIV Task You recently watched a documentary about people living with HIV in the United States. You thought the disease was nearly eradicated and are now curious to know more about the prevalence of the disease. Specifically, how many people in the US are living with HIV?
Exploratory Task—Soapbox Car Task After the NASCAR season opened this year, your niece became really interested in soapbox derby racing. Since her parents are both really busy, you've agreed to help her. The first step is to figure out how to build a soapbox derby car. Identify some basic designs that you might use and create a basic plan for constructing the car.

Table 1. Task description

Based on the result of previous study that focused on how different types of information can be useful as assistance for search tasks of differing complexity; we selected one fact-finding task (HIV task) which as believed the Factual statement would be helpful to answer, and one exploratory task (Soapbox car task) which the informed Opinion might facilitate its completion. Table 1 shows the task description of the two tasks.

3.2.3 Counterbalance

The independent variables in this study—Task complexity, Info Box position and the Info Box correlation— were within-subject variables, and each of them have two conditions. Each participant completed two total tasks, so each participant only experienced two combinations of the independent variables. In order to counterbalance

the order effect caused by subjects' learning, practice, or development of strategies, those conditions were designed to rotate across participants using a Latin Square counterbalancing method. Based on the task arrangement shown in Table 2, the search system assigned the task and interfaces in different layouts to the participants via their participant ID.

Task:
F = HIV task,
O = Soapbox Car task;
IB position:
H = Info Box loacted in the **middle,**
V = Info Box loacted on the **right side**;
IB Correlated (Type Order):
F-O=Facts-Opinions,
O-F=Opinions-Facts.

Task Order	1				2		
pID	Task	IB position	IB Correlated		Task	IB position	IB Correlated
1	F	H	Y(F-O)		O	V	N(F-O)
2	O	H	Y(O-F)		F	V	N(O-F)
3	F	H	Y(F-O)		O	V	N(F-O)
4	O	H	Y(O-F)		F	V	N(O-F)
5	F	V	Y(F-O)		O	H	N(F-O)
6	O	V	Y(O-F)		F	H	N(O-F)
7	F	V	Y(F-O)		O	H	N(F-O)
8	O	V	Y(O-F)		F	H	N(O-F)
9	F	H	N(O-F)		O	V	Y(O-F)
10	O	H	N(F-O)		F	V	Y(F-O)
11	F	H	N(O-F)		O	V	Y(O-F)
12	O	H	N(F-O)		F	V	Y(F-O)
13	F	V	N(O-F)		O	H	Y(O-F)
14	O	V	N(F-O)		F	H	Y(F-O)
15	F	V	N(O-F)		O	H	Y(O-F)
16	O	V	N(F-O)		F	H	Y(F-O)

Table 2. Latin Square Counterbalancing

For example, the subject whose participant ID was "1" performed the HIV task (task = F) with the search assistance tool located in the middle of the search results horizontally (IBposition = H) in which the "Fact" box was placed on the left and the "Opinion" box was on the right (meaning that the task and the first IB position on the left were correlated in that they both focused on facts). For the second task, participant 1 was then asked to search for the Soapbox Car task (task = O) with the InfoBox tool placed on the right side of the SERP vertically (IBposition = V) where the "Fact" box was located

above the “Opinion” one (this is correlated = N because the task is thought to involve opinions, but the top IB box showed “Facts”).

3.2.4 Subjects

Given the consideration that the sampling size was 12-16 participants and the scope was the UNC students who are at least 18 years old, fluent in English (reading, writing, and speaking) and has no previous experience of participating study in the Interactive Information Systems Lab; we reached out to UNC specific departments—Political Science, Sociology, and School of Information and Library Science—and asked them to distribute the recruiting email (Appendix 1). The students who showed their interested in this study were asked to schedule the study time using a form on the Bookings tool from Microsoft available through UNC. In addition, a reminder email was sent to the participant one day before the study was conducted. Overall, the study included 12 participants using the first twelve experiment task ordering shown as the first twelve rows of Table 2.

3.2.5 Data Collection

Both the qualitative and quantitative data were collected in this study. The qualitative data was collected from the answers to the retrospective video-stimulated recall interview, which helped us to understand participants’ insights behind their behaviors, as well as their expressed engagement with the search assistance tool. The quantitative data were from: 1) the demographic data collected from the entry questionnaire, 2) the pre-task, post-task questionnaires, 3) the eye gaze data collected

through the Tobii eye-tracking hardware and software (Tobii Studio), and 4) the mouse and click events recorded from custom logging software and through Tobii Studio.

4. Data Analysis & Result

4.1 Subject Demographic

In this study, we successfully recruited 12 participants among which six participants are studying in School of Information and Library Science, four of them are from Political Science, one major in Business Administration and one is studying in Sociology. Also, this study has covered the participants from different education levels—five of them are graduate students and seven are undergrads.

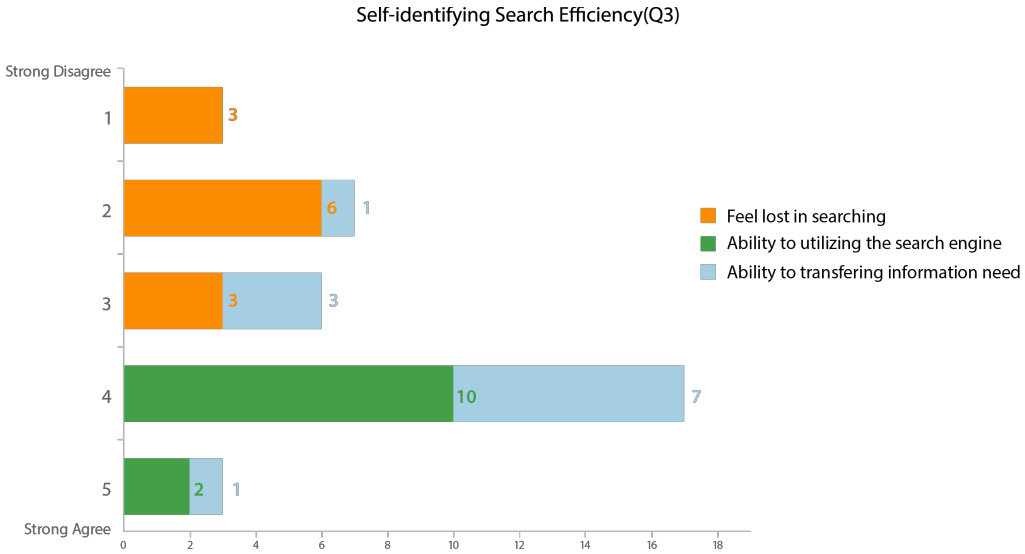

Figure 1. Pre-task Question—Self-identifying Search Efficiency

With the aims of understanding their web searching literacy, we included three questions related their search efficiency, the participants were asked to select their level of agreement on 5-point scales (1=strongly disagree, 5=strongly agree) for three statements about self-identifying search efficiency (The full text of the questions is

shown in the Appendix 3). As shown in Figure 1, all the participants agreed that they could utilize the search engine well and would not feel confused very often while searching online; while four participants didn't think they could write effective query during the search.

4.2 User Engagement (Quantitative Results)

4.2.1 Overview

To explore the difference of user engagement quantitatively, I analyzed the results from the post-task questionnaire, the eye-gaze data, as well as aligning the eye-gaze data with mouse events. No significant difference was found from the questionnaire data, however, gathering from the measures of eye-gaze data and the mouse events, I found that participants were easier to notice the assistance tool placed in the middle while the one on the right side had more interaction with the participants who used it.

4.2.2 Post-task questionnaire

The post-task questionnaire was partially adapted from the UES-Short Form which originally has 12 questions in four subscales—focused attention, perceived usability, aesthetic appeal, and reward factor. Focused attention (FA) means the extent of feeling absorbed during the interaction and losing track of time; perceived usability (PU) is related to users' affective and cognitive responses to the system (O'Brien & Toms, 2013); aesthetic appeal (AA) scales the user perception on the visual outlook of the interface; and the reward factor (RW) is a single set of items made up of 1) user overall success of the interaction, 2) novelty and interest in the task, and 3) the extent to involve in the task (O'Brien & Toms, 2013). Given the consider that there is vaguely different

between two interfaces from the perspective of appearance, we decided to exclude those three questions related to the AA and selected others into the 5-point scales post-task questionnaire (1=strongly disagree, 5=strongly agree). In addition, two more questions in the same scale was added with the aim of gathering the user opinion about the information quality on the system (See Appendix 5 for the full text of the post-task questions).

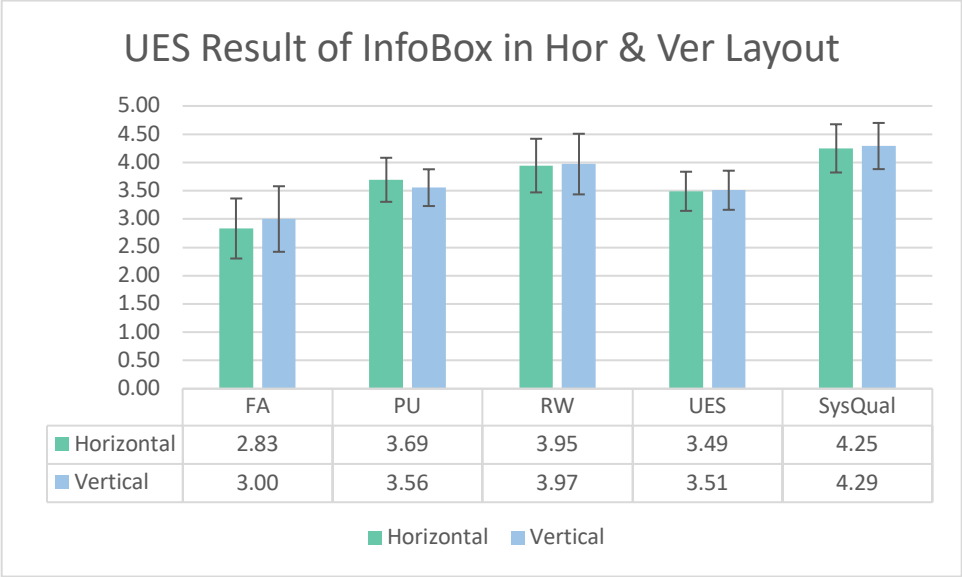

Figure 2. UES Score—Search System with InfoBox tool in the Middle ("Horizontal") and that on the Side ("Vertical")

In order to compare the user engagement with different interfaces, the post-questionnaire results were grouped by the InfoBox positions (Horizontal and Vertical) and measured separately. Followed by the instruction of scoring UES-short form from (O'Brien et al., 2018), the PU score was firstly reversed and then the score of each subscale was calculated by its average; the overall user engagement (UES) was considered as the average of those three subscales. And the system quality (SysQual) was measured by the average of two questions. The Figure 2 shows the means and 95% confidence intervals of the overall UES measurement results and the system quality score

of the search system with search assistance tool in the middle (green color in Figure 2) and that on the right side (blue color in Figure 2).

As Figure 2 shows, only slightly different is observed based on the post-task questionnaire results between the search assistance tools in different positions, not only reflected on the UES score, the similarity is also shown in each subscale score with similar confidential interval. It indicates that the variation of the user engagement within search assistance tool in different position isn't shown through the post-task questionnaires.

4.2.3 Eye Gaze Data

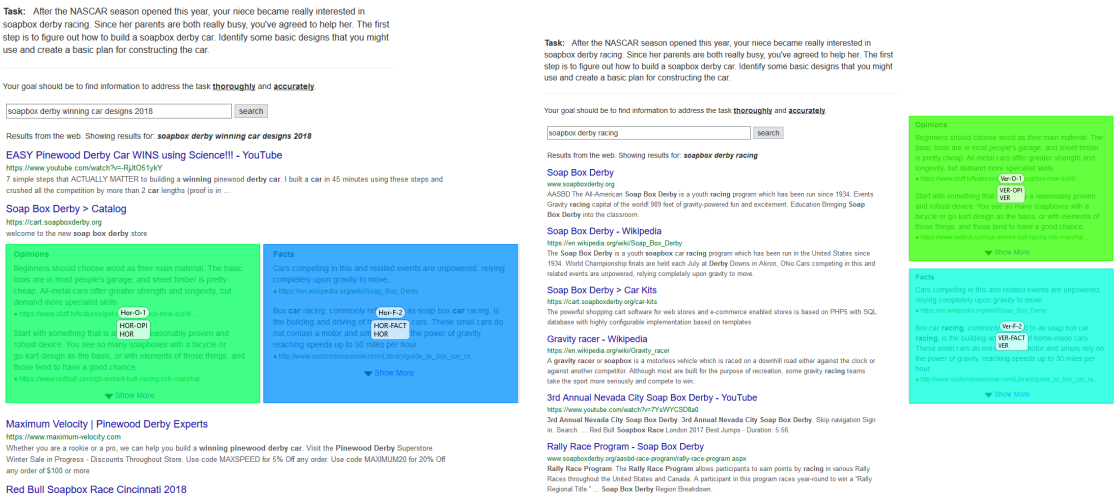

Figure 3. Area of Interest (AOI) on the search system in different layouts

Area of Interest is one of built-in tools in the Tobii Studio which allows the researchers to get statistics for eye tracking metrics, such as *Time to First Fixation* or *Visit Count* for areas they are interested in for one/many recordings by drawing ellipses, rectangles, or polygons (Tobii, 2016). To exploring the user's attention on the search assistance tool, we draw AOI rectangles on the InfoBox from which SERP the participants had opened during the study. "Fact and "Opinion" were marked as

independent AOI on each page and grouped by both the layout and the information type so as to compare the data across the medias. For example, as shown in Figure 3, on the left, the AOI of "Opinion" was drawn and named by "Hor-O-1", also it was marked as belonging to the "HOR-OPI" AOI group and the "HOR" AOI group; while the "Fact" AOI was outlined and named as "Hor-F-2", grouped with the "HOR-FACT" as well as the "HOR". To compare the effect of the positions, we mainly focused on two AOI groups —the "HOR" group which contains the area of the tool when it was in the middle, and the "VER" group which include the area the tool placed on the right side.

Based on the AOI and AOI groups, we used the Tobii Studio embedded Statistics tool to calculate eye tracking metrics. As shown in Table 3, we processed five metrics to compare the participants' attention on the InfoBox tool in different layouts; each participant was identified as an individual, the "middle" and the "side" in the table are related to the InfoBox located at different positions-- in the middle ("HOR") and on the right side ("VER"). The metrics we used are: 1) Time to First Fixation, 2) Total Fixation Duration, 3) Total Visit Duration, 4) Fixation Count, and 5) Visit Count. Next, each metric will be introduced separately and followed by the results we found on it:

1). **Time to First Fixation** measured the time it took before the participants fixated on the AOI group for the first time. It started when any SERP with InfoBox tool firstly displayed and stopped at the time the participants first fixated on it. If during the study, the participant had no fixation on the AOI group, it would not be computed and represented as a "-" in the table.

2). **Total Fixation Duration** described the sum of the duration for all fixations from a participant within an AOI group. If at the end of the study, the participant had not fixated on that group, it would be registered as "0".

3). **Total Visit Duration**, different from the *Total Fixation Duration* which only included the fixation time in the AOI group, *total visit duration* recorded the sum of each visit duration—the time between the fixation on the AOI and the next one outside the AOI group. This could be explained why the value of the *Total Fixation Duration* was slightly smaller than this metric in Table 3.

4). **Fixation count** described the number of times a participant fixated on the AOI group while 5). **Visit count** calculated the number of visits within an AOI group, that is to say, it records the back and forth the participants looked between the InfoBox tool and the rest of the page.

	Time to First Fixation		Total Fixation Duration		Total Visit Duration		Fixation Count		Visit Count		Fixation c. - Visit c.	
PID	Middle	Side	Middle	Side	Middle	Side	Middle	Side	Middle	Side	Middle	Side
1	3.29	75.43	5.28	0.28	5.28	0.28	20	1	11	1	9	0
2	11.12	8.21	1.4	**24.09 F**	1.4	**25.13 F**	7	**107 F**	5	**13 F**	2	**94 F**
3	5.23	-	**12.59 F**	0	**12.59 F**	0	**38 F**	0	**5 F**	0	**33 F**	0
4	40.7	-	1.28	0	1.28	0	5	0	5	0	0	0
5	7.88	-	9.33	0	9.54	0	31	0	12	0	19	0
6	7.89	77.99	2.85	1.62	2.85	1.62	12	7	7	3	5	4
7	1.85	4.05	3.26	**31.11 F**	3.26	**31.11 F**	15	**110 F**	11	**19 F**	4	**91 F**
8	3.96	3.48	**9.77 F**	**9.85 O**	**9.77 F**	**9.85 O**	**35 F**	**33 O**	**6 F**	**6 O**	**29 F**	**27 O**
9	16.99	38.22	3.84	2.74	3.84	2.74	17	8	12	3	5	5
10	4.93	-	6.7	0	6.7	0	24	0	14	0	10	0
11	2.64	21.76	**7.81 F**	**25.09 O**	**7.81 F**	**25.09 O**	**33 F**	**109 O**	**7 F**	**14 O**	**26 F**	**95 O**
12	12.65	1.55	1.68	0.4	1.68	0.4	6	2	3	1	3	1
MEAN	9.93	28.84	5.48	11.90	5.50	12.03	20.25	47.13	8.17	7.50	12.08	39.63
SUM	119.13	230.69	65.79	95.18	66.00	96.22	243	377	98	60	145	317

Table 3. Eye Tracking Metrics of the InfoBox AOI groups

To interpret the use of InfoBox tool by eye-gaze data, we took the data recorded from the custom logging software to define the actions of clicking the URLs/buttons in the InfoBox tool as effective interactions with the tool. In Table 3, for those experiences the participants had interacted with the InfoBox tool, the data from which was marked in bold and followed by the type of task they were performing ("F"=HIV task,

"O"=soapbox derby car task). The average of each metric is calculated by excluding the individuals who had no fixation during that time, in other words, for the average of metric recording the fixation data of the tool on the side, they were summed and divided without those "0" values.

For the *Time to First Fixation*, the mean of that on the side InfoBox (AVG = 28.84s) is much larger than the mean of the that in the Middle one (AVG = 9.93s); in addition, associating with the fact that there were 4 participants who had no fixations on the side InfoBox, this metric showed that the assistance tool in the middle was easier to be noticed by the participants.

Given the consideration that regardless of whether the eye-gaze measures imply that user engaged with the assistance tool, if the users didn't feel themselves engage in, we couldn't tell such fixations were valuable or had positive impact on the engagement with the rest of the system. For this reason, with regard to other metrics, we decided to focus on those records which have effective interaction on the InfoBox so as to analyze the engagement with the tool as well as the rest of the system.

According to the order of the task assigned to the participants, half (6) of them did the fact-finding task in the context of the InfoBox placed in the middle and vice versa. By looking at the mean values of the *Total Fixation Duration*, it seemed that participants expensed more time on the right side one. Including the task type into the consideration, for each time the middle tool was utilized, the participant was performing the fact-finding task (which overall required less time), while the side tool was used two times in the fact-finding task and two times in the exploratory task. This may partially explain the variation. On the other hand, it's observed that while performing the fact-finding task, the

fixation time the participants spent on the middle tool (p3=12.59s; p8=9.77s; p11=7.81s) was shorter than other two participants took on the side tool (p2=24.09s; p7=31.11s).

For the *Visit Count*, which reflected the participants' eye movement between the InfoBox and the rest of the page, it showed that for the subjects who interacted with the tool (i.e., data formatted in bold and marked with "F" and "O" in Table 3), they had more movements between the side tool and the rest of the page rather than the middle one. By seeing the difference between the *Fixation Count* and the *Visit Count* of the subjects who used the tool, the value of that related to the side tool was larger than the middle. This could indicate that the participants who interacted with the InfoBox paid more attention to the content of it when placing on the right side.

4.2.4 Click Events & Eye Gaze Data

Two types of mouse events on the InfoBox were collected from the custom logging software. As shown in the Table 4 they were: 1) the number of clicks on the source URL listed on the InfoBox, and 2) the number of clicks on the "Show More" button to expand and show all the 10 results. The "Gaze Data" in the table means whether participants had ever fixated on the InfoBox during the task. In addition, in order to differentiate the situation that the participant saw the tool unconsciously and they actually noticed its existence, we added the "Notice" column in the table which the data was collected from the question "*Do you remember seeing the InfoBox tool on this search page?"* in the retrospective recall interview. For example, the eye tracker recorded participant 1 fixated on the InfoBox in the middle when they were performing the HIV task, and they mentioned in the retrospective interview that they did notice the tool during the search, however, they didn't take any action with it (source clicks = 0, show

more = 0). When they were performing the Soapbox Car task, their fixation on the InfoBox placed on the right side had also been tracked, but they didn't report during the interview that they noticed the tool; in addition, no interaction had been recorded between the tool and the participant in this task.

	Middle					Side				
PID	Task	Gaze Data	Notice	Source Clicks	Show More	Task	Gaze Data	Notice	Source Clicks	Show More
1	F	Y	Y	0	0	O	Y	N	0	0
2	O	Y	N	0	0	**F**	**Y**	**Y**	**1**	**1**
3	**F**	**Y**	**Y**	**1**	**0**	O	N	N	0	0
4	O	Y	Y	0	0	F	N	N	0	0
5	O	Y	Y	0	0	F	N	N	0	0
6	F	Y	N	0	0	O	Y	N	0	0
7	O	Y	NOT SURE	0	0	**F**	**Y**	**Y**	**0**	**1**
8	**F**	**Y**	**Y**	**1**	**0**	**O**	**Y**	**Y**	**1**	**0**
9	F	Y	Y	0	0	O	Y	Y	0	0
10	O	Y	Y	0	0	F	N	N	0	0
11	**F**	**Y**	**Y**	**1**	**0**	**O**	**Y**	**Y**	**3**	**0**
12	O	Y	N	0	0	F	Y	N	0	0
COUNT	-	12	8	3	0	-	8	5	3	2

Table 4. Click Event & Eye Gaze Data of InfoBox in Two Positions

Across both tasks, five of the 12 participants clicked on the InfoBox tool during at least one of the tasks (p2, p3, p7, p8, p11). Two participants used the InfoBoxes in both layouts (p8, p11); one participant clicked the source in the InfoBox only when it was placed in the middle (p3), while two participants only use it when it was on the right side (p2, p7). In other words, 3 of 12 participants interacted with the InfoBox in the middle and they all agreed that they gained useful information from the tool; 4 of 12 participants interacted with the tool on the right side among which one of them reported that they didn't gain anything useful from looking at it.

Looking at the data separately, all the participants (12) fixated on the InfoBox placed in the middle, however, three of them didn't think they had ever noticed the tool while performing the task. Interestingly, for the rest of the participant who reported noticing tool, there are five participants who noticed the InfoBox but didn't choose to do any further action with it. This is different from the data of the InfoBox on the right side: 8 of 12 participants fixated on the InfoBox and five of them reported their notice of the

InfoBox tool, among which there is only one participant who detected the tool but not interacted with it.

4.3 User Engagement (Qualitative Result)

4.3.1 Use & Gain from the Box in the Middle

For the three participants who were able to use the InfoBox in the middle, in describing about when and what exactly drew their attention, one of them thought they noticed it immediately by seeing the "Fact" title in the box; the other two reported that they didn't see it immediately: one mentioned that it was a number (e.g. statistic) in the InfoBox that drew their attention when they just decided to find this type of data, while another participant scanned the page from top to bottom carefully and thought the rectangle format made the tool stand out and led them to see the numbers there.

Explaining why they (8/12) didn't notice/use the InfoBox tool in the middle, three participants mentioned assuming that there were advertisements or something irrelevant in the boxes; 2/8 participants mentioned that their previous search experience might have influenced their impression: they didn’t think the assistance provided by the search engine were helpful so they usually ignored it. Two participants mentioned that the format/content provided in the InfoBox wasn’t attractive to them, among which one mentioned that the pictures or instructions was what they would go to first (in Soapbox Car task) and the other was looking for some specific numbers (in HIV task) at that time. To be noticed, for the one who was looking for numbers, the “Fact” box was placed on the right in the middle. The credibility of the source is another factor mentioned by two participants when talking about why they noticed the tool but not used it.

4.3.2 Use & Gain from the Box on the Right Side

2 of 4 participants among who used the InfoBox placed on the right side thought the content in the tool was the thing drew their attention, and they commented on this as follows:

> "I saw something about 'materials' which made me curious about what type of materials should use to build the car, and that's the reason I clicked that link." (P8)

> "It was almost the first thing I saw…I think when I saw the numbers, when I was trying to find the exact number to answer the question, the box on the right stand up to me because there were more numbers popping out." (P7)

One of them noticed the tool when they were waiting the page switching and they thought the format looked like it would provide information in an easy way which the original results did not. And the other one mentioned it was the time when he couldn't find anything on the links on the left side; then they "*realized to look on the right*".

Based on the result that seven participants didn't notice the InfoBox on the right side, five of them stated that they were more focusing on the main search area and they didn't usually pay any attention on the right side no matter there was some information or advertisement there. The participant 5 expressed this as followed:

> "… because I didn't expect anything that would be there, and focus on the output of the results… you know, sometimes I won't close the pop-ups on the right side, I usually just ignored it."

One participant explicitly expressed the confidence of their search capability, and defined themselves as "*pretty good at searching for exactly what I need*"; as a result, they usually search by themselves.

Different from the fact that there were five subjects who noticed the InfoBox in the middle and ignored it, only one participant noticed the tool on the right side without

using it. During the task, they noticed the tool when waiting for the page switching and they stated that they didn't really absorb any useful information in the boxes during that short time.

4.3.3 Preference on the Positions

Overall, when asked the preference of the InfoBox position, most of the participants inclined to have it in the middle as to notice its existence; on the other hand, with the knowledge that the content in the InfoBox is relevant, some participants are more willing to have it on the right side to make the page cleaner.

Specifically, for the two participants who used the InfoBox on both positions, they all preferred to have the tool in the middle of the page. They explicitly mentioned that placing the InfoBox in the middle helped them to notice the tool faster than that on the right side, also they thought they paid more attention on the tool in the middle than the other one. Partially, the quick notice could be ascribed to the number (e.g., the HIV statistic) shown in the content and their search behavior—by default, they don't usually pay much attention on the right side. While talking about this, both of the participants pointed out their search experience on Google as follows:

> "When it was on the side, part of my brain was kind of like 'Oh, it was an advertisement' and that was another reason I didn't look at it immediately, because I assumed that this was Ads and I didn't want to look at it…And I know on Google normally that would be an Ad, so part of my brain immediately assumed to think it was an Ad, and after I was kind of realizing it wasn't." (P8)

Generally, 8 of 12 participants preferred the middle position, among which six of them explained the reason behind it was that they would associate things in this position with advertisements because Google put the advertisements there, which made them to ignore things on that position. As participant 9 noted:

> "… I think I like boxes …because on the side it seems irrelevant, because Google on the side they get Ads or prompting something irrelevant."

Three participants mentioned that the middle position was more appealing and one of them also stated the position on the right side would make them ignore the tool. Additionally, one of the participants who inclined to the tool on the right side declared that if it placed in the middle, they would get distracted; this, on the other hand, supports the idea that the middle position was more noticeable than the right side.

There are four participants be more willing to have the tool on the side, two of them indicated that it would make the layout of the page cleaner with knowledge of the tool would be there:

> "Perhaps on the side would be better because I know it's there and its separate from the rest of the everything. It's cleaner, like better design… it isn't disrupted but it was there if I want to look at them." (P4)

For the other two, they thought the tool on the right side was more standing-out and distinguish from the left a lot more compared to the one in the middle.

> "…It (right side) just stood out, it helped me to catch my eye on it more." (P2)

Considering that both participants interacted with the box on the right side with the HIV task and experienced the box in the middle with the soapbox task, we thought part of the distinguish might be assigned to the variation of the content in the InfoBox.

4.3.4 Content Relevance to the Task

For the participants who used the InfoBox placed in both positions, one stated that the "Fact" type of information was helpful to the fact-finding task (HIV task), and the "Opinion" type of information helped them to complete the exploratory task (Soapbox task); another participant indicated that they did not notice the different types of

information hugely, instead, they were more focusing on one of the boxes during the search.

We also asked other participants whether these two types of information would provide dissimilar assistance in different tasks; for the fact-finding task, we got consistent statement that the "Fact" would be more helpful; while for the exploratory task, six participants opined that the "Opinion" would provide useful information while five participants supposed that they would rather see some pictures or list of instructions in the tool to help them finish up the construction plan of a Soapbox car.

4.4 Factors Affect the Use of InfoBox

4.4.1 The Authority of Source

During the retrospective interview, three participants mentioned the source of information the InfoBox provided when talking about the motivation to use/not use it:

- One participant clicked the link after figuring that its source was reliable.
- One participant opined as followed as talking about the reason why they noticed the tool but not used it:

  "…… I didn't know the resource of that information so I would rather focus on finding the credible source." (P5)

- One of the interesting observations is that there is one participant, at the very beginning of their task, seeing the boxes and clicking "show more" on the Fact box to go through the information, then they asked if they need to keep searching. The moderator then indicated "yes" and after this the participant was more focused on the links on the left and didn't take any further action with the boxes. Asked the reason of this particular action during their search, they said they'd

already known the answer to the task by looking at the first subtext in the InfoBox; and in order to double check the number of populations, they chose to look at the links on the left. Also, they expressed their concerns about the authority of the sources listed in the box by saying that:

> "I'm not sure where they getting that information from, so I did more research on the left to ensure that the information is trustful." (P7)

Additionally, when asking about the preference of the InfoBox position, one participant related it with the trustful of the content by saying that:

> "If the idea is to get me to see the boxes, I would prefer this layout (in the middle) … if I knew that I could trust the content in the boxes, I would want them there, if I did not know that, they would prefer it on the side that I could ignore them." (P5)

This, on the other hand, reflected the relation between the source authority and making the decision to click the link to get more information.

4.4.2 Things That Block the Scent

Noticing that only a few participants had interacted with the InfoBox tool, we wanted to dig deeper to interpret the reason behind it. Going back into the eye movement data, some of the information foraging behaviors were observed when the participants were interacting with the SERP, and we believe there are some factors in this study blocking out the scent of the InfoBox tool, which may have affected its use or notice.

Camouflage Links

Taken from the observation, there is a common action of six participants occurred when they were interacting with the system, which the InfoBox was in the middle: they only read over the titles of the search results and naturally skipped the tool as to look at the next one (For the participants who roughly read the search results and scrolled the

page up and down didn't take into account). Four of them explicitly mentioned that it was because they direct their attention straight to the blue text—the title of each link (See the examples of eye-gaze pattern in Appendix 8):

> "I was like looking for the blue...I was looking for the titles of different pages and this looked like something else, it wasn't the same format, so this not let me interested in." (P4)

This phenomenon also has also been observed in other eye-tracking research like (Maynes & Everdell, 2014) that users are still looking of the list of search results when new elements are introduced to the SERP, they would be distracted by those elements but not really pay much attention to it. Diving into such "distraction but not attention", some participants related their search experience with their common-used search engine and commented that:

> "Since it seemed like what Google provided to you and I didn't find it's useful on Google, so I would prefer naturally read the title and its description and search by myself." (P10)

Banner Blindness

As stated earlier, in total, there were seven participants who didn't notice the InfoBox tool placed on the right side—no fixation was tracked from four participants and fairly low visit duration was recorded from the other three participants (See the examples of eye-gaze pattern in Appendix 9). According to the interview, we noticed that those participants ignored the area on the right side due to their knowledge of the advertisement or something irrelevant tend to be placed there. This observation matched the findings from (Nielsen, 2007) that users come to disregard specific regions of the web page if they unconsciously assign that area with the irrelevant information. The participants' previous search experience as well as the experience of scanning some webpages during the task

may have built up such association over time. In addition, we believe this may be a type of search habits that cannot be easily changed; which, somehow, had been reflected on the answers collected from the retrospective interview—during the search, eight participants related the right area as advertisements or irrelevant information, while four participants have the similar assumption of the tool in the middle area and two participants associated it with not helpful information.

4.4.3 Effects of Task Type

The effect of the task type was mainly reflected on providing some trace of the InfoBox tool's existence. For the participants who found and used the InfoBox in the fact-finding task (HIV task), three of them explicitly mentioned that it was the number in the InfoBox content that drew their attention:

> "…I went back to read what the prompt was, and I realized I was just looking for numbers and that's the time I saw the box, the number in it was immediately in my eyes." (P8)

Addedly, two participants who used the InfoBox on the side in HIV task stated that they preferred the tool on the side because it was more popping-out especially when included the content with some numbers:

> "Just because I can see it, it stood out to me more. I feel like it would be useful to have like the information for first task, if you're looking up certain number and stuff, and to have it show right away on the right corner, so you don't have to keep searching...." (P7)

On the contrary, placing the information assistance for the exploratory task in the middle made the information mixed together with the results and this seemed to have a negative impact on participants figuring out the InfoBox.

4.4.4 Possible Use Scenarios

During the interview, six participants expressed some situations in which they would like to use the InfoBox. Standing in the context of searching something really quick, such as movie star, and populations, three participants identified the InfoBox as a fast pass or a summary to access the answer:

> "I would like to use it to search for some real quick fact, like the HIV task, … or something I know nothing about it, like the name of a movie." (P7)

One participant, on the other hand, didn't think the information the tool provided would directly tell them the answer. While practicing some complex task searching, two participants regarded the InfoBox as a guidance by commented that:

> "…the content in the box was a good place to start… and I feel like deeper diving into other search results then was also helpful…" (P11)

> "If there is a topic I don't know anything about it, I might use it to kind of guide me....." (P9)

On the contrary, one participant mentioned that they won't use the tool when facing with complex searching task, because they thought the information in it was not enough to provide comprehensive information, as a result, they would prefer to search by themselves.

5. Discussion

This study aims to explore whether there was an effect of the relationship between the search assistance tool's position on the SERP and the user engagement during the search. Overall, according to the quantitative data, we found that the search assistance tool placed in the middle got easier attention from the participants, while the one on the right side attracted more interactions during the use. To investigate the insight behind such differences, we analyzed the qualitative data we collected from the retrospective recall interview and we found that people had different interpretations on these two positions: the middle is more reliable than the side, on the other hand, placing the tool on the right side made the page cleaner. However, considering that most of the participants didn't use the tool even though they noticed that when it was in the middle, we were still curious about the reason behind this observation. The interview from this study also provides some insights about factors that affect the participants using the assistance tool. Their concerns about the information credibility is one of them, also based on what we learned from the retrospective interview, we believe the design of the assistance tool was kind of blocking the information scent from the participants. In addition, we cannot rule out the effect of the task type on the user engagement with the search assistance tool in different layouts.

In order to reaching out and recruiting the proper number of participants, instead of sending the email to all the UNC students on campus, we chose several departments

to send out the emails and which may constrain the results to be generalized to represent the overall student population. However, we didn't restrict the scope into single school or department, especially, we controlled the number of participants from SILS as to have half of participants who were from SILS and half of them who are from other departments. This aimed to recruit participants with diverse computer literacy. At the beginning of the study, we planned to recruit 16 participants using the experiment ordering to counterbalance the order effect; however, due to the time constraints, we ended up the experiment by 12 participants, which made the results cannot fully rule out the effect of the task type. Based on the current results, 6/12 participants have faced with the InfoBox in the middle with fact-finding task and 6/12 participants have performed the exploratory task within the interface having the InfoBox on the right side. We believed that this basically helped to counterbalance the task type effect and the order effect caused by 12 participants was more related to the internal position of the information inside the tool (for example, whether the information placed on the left/above is correlated with the type of task). The results of the pre-task questionnaire which related to their pre-knowledge and prejudgment of the task was not included in the analysis. This might have influence on their performance during the task.

6. Conclusion

My goal in this study was to explore the difference of user engagement with a search assistance tool in different positions on a SERP. I investigated this by designing and conducting an eye-tracking usability study with 12 UNC-CH students. Both quantitative data and qualitative data were collected to interpret their engagement with the search assistance tool in two positions: 1) search assistance tool placed under the top two search results, 2) search assistance tool placed to the right side of page. The quantitative data were analyzed in three aspects—answers to the post-task questions (adapted from the UES-SF), measures generated from the eye-gaze data, and click events aligning with the eye-gaze data. Although there was no significant difference observed in the post-task questionnaire answers, we noticed some differentiation from the eye-gaze data and click events. The search assistance tool placed in the middle appears to be noticed by more participants. However, when placed on the right side, participants appear to spend more time and effort engaging with it. The qualitative data gathered from the retrospective interview has also reflected this on their preference of the search assistance tool position. Some participants thought placed it in the middle was easier to be found and on the other side, they preferred the right-side position if they had the knowledge of the existence of the tool. In addition, we also found some factors that influence the notice/use of the search assistance tool from the retrospective interview. Firstly, the source authority has a substantial impact on the use of the search assistance

tool. Secondly, common issues like camouflage links, banner blindness, were observed which may block the information scent of the search assistance tool. Also, individual search preference and the type of tasks may influence on the use/notice of search assistance tool on SERP.

My findings reveal that the search assistance tool in different positions affect its notice and use reflected both on time and effort people spent. Additionally, people have various perceptions of information placed in different positions on a SERP. The results of this study would be helpful for the future development of the InfoBox system project on some decisions related to the design and position. Also, it would be useful to other researchers who are working on search assistance tools by providing some insights of how user related the positions to the relevance of the information.

7. Acknowledgement

This project would not be possible without the help of my supervisor—Dr. Robert Capra who continues providing suggestions and keep me on the right track, Austin Ward who was always willing to provide the technical support on implementing the changes of the InfoBox system, and Anita Crescenzi who gave me huge support on learning the eye-tracking devices and knowledge.

8. Bibliography

1. Albers, M. J., & Mazur, M. B. (Eds.). (2014). Content and complexity: information design in technical communication. Routledge.
2. Arguello, J., & Capra, R. (2014, November). The effects of vertical rank and border on aggregated search coherence and search behavior. In Proceedings of the 23rd ACM International Conference on Conference on Information and Knowledge Management (pp. 539-548). ACM.
3. Aula, A., Majaranta, P., and Raiha, K.-J. (2005). Eye-tracking reveals personal styles for search result evaluation. INTER- ACT, 1058–1061.
4. Bannon, L. J. (2005). A human-centred perspective on interaction design. In Future interaction design (pp. 31-51). Springer, London.
5. Banhawi, F., & Ali, N. M. (2011, June). Measuring user engagement attributes in social networking application. In 2011 International Conference on Semantic Technology and Information Retrieval (pp. 297-301). IEEE.
6. Bota, H., Zhou, K., & Jose, J. M. (2016, March). Playing your cards right: The effect of entity cards on search behaviour and workload. In Proceedings of the 2016 ACM on Conference on Human Information Interaction and Retrieval (pp. 131-140). ACM.
7. Capra, R., Arguello, J., Crescenzi, A., & Vardell, E. (2015, August). Differences in the use of search assistance for tasks of varying complexity. In Proceedings of the

38th International ACM SIGIR Conference on Research and Development in Information Retrieval (pp. 23-32). ACM.

8. Chowdhury, S., Gibb, F., & Landoni, M. (2014). A model of uncertainty and its relation to information seeking and retrieval (IS&R). Journal of Documentation, 70(4), 575-604.
9. Dumais, S. T., Buscher, G., & Cutrell, E. (2010, August). Individual differences in gaze patterns for web search. In Proceedings of the third symposium on Information interaction in context (pp. 185-194). ACM.
10. Enable Search result features for your site - Search Console Help. (2019). Retrieved from https://support.google.com/webmasters/answer/7358659?hl=en
11. Featured snippets in search - Search Console Help. (2019). Retrieved from https://support.google.com/webmasters/answer/6229325?hl=en
12. Fulmer, S. M., & Frijters, J. C. (2009). A review of self-report and alternative approaches in the measurement of student motivation. Educational Psychology Review, 21(3), 219-246.
13. Granka, L. A., Joachims, T., & Gay, G. (2004, July). Eye-tracking analysis of user behavior in WWW search. In Proceedings of the 27th annual international ACM SIGIR conference on Research and development in information retrieval (pp.478-479). ACM.
14. Guan, Z. and Cutrell, E. (2007). An eye tracking study of the effect of target rank on web search. Proc. CHI, 417–420.
15. Laurel, B. (2013). Computers as theatre. Addison-Wesley.
16. Lagun, D. and Agichtein, E. (2011). ViewSer: Enabling large-scale remote user

studies of Web search examination and interaction. SIGIR, 365–374.

17. Lagun, D. and Agichtein, E. (2011). ViewSer: Enabling large-scale remote user studies of Web search examination and interaction. SIGIR, 365–374.
18. Lorigo, L., Pan, B., Hembrooke, H., Joachims, T., Granka, L., and Gay, G. (2006). The influence of task and gender on search evaluation and behavior using Google. IP&M, 42(4): 1123–1131.
19. Liu, Z., Liu, Y., Zhou, K., Zhang, M., & Ma, S. (2015, August). Influence of vertical result in web search examination. In Proceedings of the 38th International ACM SIGIR Conference on Research and Development in Information Retrieval (pp.193-202). ACM.
20. Maynes, R., & Everdell, I. (2014). The evolution of Google search results pages and their effects on user behavior [PDF file]. USA: Mediative. Retrieved from https://www.slideshare.net/GerardoEJuarez/the-evolution-of-googles-search-results-pages-effects-on-user-behaviour
21. Melucci, M., & Baeza-Yates, R. (Eds.). (2011). Advanced topics in information retrieval (Vol. 33). Springer Science & Business Media.
22. Nielsen, J. (2007). Banner blindness: old and new findings. Retrieved from https://www.nngroup.com/articles/banner-blindness-old-and-new-findings/
23. Navalpakkam, V., Jentzsch, L., Sayres, R., Ravi, S., Ahmed, A., & Smola, A. (2013, May). Measurement and modeling of eye-mouse behavior in the presence of nonlinear page layouts. In *Proceedings of the 22nd international conference on World Wide Web* (pp. 953-964). ACM.

24. O'Brien, H. L., & Toms, E. G. (2010). The development and evaluation of a survey to measure user engagement. Journal of the American Society for Information Science and Technology, 61(1), 50-69.
25. O'Brien, H. L. (2010). The influence of hedonic and utilitarian motivations on user engagement: The case of online shopping experiences. Interacting with computers, 22(5), 344-352.
26. O'Brien, H. L., & Toms, E. G. (2013). Examining the generalizability of the User Engagement Scale (UES) in exploratory search. Information Processing & Management, 49(5), 1092-1107.
27. O'Brien, H. L., Cairns, P., & Hall, M. (2018). A practical approach to measuring user engagement with the refined user engagement scale (UES) and new UES short form. International Journal of Human-Computer Studies, 112, 28-39.
28. Pan, B., Hembrooke, H., Joachims, T., Lorigo, L., Gay, G., & Granka, L. (2007). In google we trust: Users' decisions on rank, position, and relevance. *Journal of computer-mediated communication*, *12*(3), 801-823.
29. Rodden, K. and Fu, X. (2007). Exploring how mouse movements relate to eye movements on web search results pages. SIGIR Workshop on Web Info. Seek. and Interact., 29–32.
30. Rodden, K., Fu, X., Aula, A., and Spiro, I. (2008). Eye- mouse coordination patterns on web search results pages. Ext. Abstracts CHI, 2997–3002.
31. Rose, D. E., & Levinson, D. (2004). Understanding User Goals in Web Search." Proceedings of the 13th international conference on World Wide Web, New York, NY, USA.

32. Thomas, P., Scholer, F., & Moffat, A. (2013, December). What users do: The eyes have it. In Asia Information Retrieval Symposium (pp. 416-427). Springer, Berlin, Heidelberg.

33. Tobii, A. B. (2016). Tobii Studio user' s manual v3. 4.5. Retrieved from https://www.tobiipro.com/siteassets/tobii-pro/user-manuals/tobii-pro-studio-user-manual.pdf

Appendix 1 Recruiting Emails

[Recruitment Email]

To: Informational email list for UNC students
Cc: ***[INSERT RECRUITING EMAIL ADDRESS]***
Subject: Participants needed: Web search system usability study
----- Message Text -----

We are recruiting participants for a research study to help us understand how people use search engines to find information on the Internet.

If you volunteer and are scheduled for this study, you will complete a series of search tasks and answer questions about your experience. To gain insights, as part of the study, we will use an eye-tracker to track what you look at on the screen. You will receive $15 for participating.

This research study will take approximately 45 minutes to complete. Sessions will be held in the Interactive Information Systems Lab on-campus in Manning Hall (next to Lenoir).

We are currently scheduling study sessions with UNC students who are at least 18 years old, fluent in English (reading, writing, and speaking) and who has never participated in a study held in Interactive Information Systems Lab before.

To sign-up to participate in the research study, visit ***[INSERT URL to questionnaire in Qualtrics]*** to provide contact information and to let us know times when you are available to participate in the study.

You can contact the researchers by sending an email to ***[INSERT EMAIL ADDRESS]***.

Many Thanks,
Yu Yuan, Principal Investigators | Rob Capra, Faculty Advisor School of Information and Library Science
University of North Carolina at Chapel Hill

You will not be offered or receive any special consideration if you take part in this research; it is purely voluntary. This study ***[INSERT IRB NUMBER]*** has been reviewed by the UNC Non-Biomedical Institutional Review Board and was approved ***[##/##/####]***.

[Reminder Email]

To: participant's preferred email address
Cc: ***[INSERT RECRUITING EMAIL ADDRESS]*** Subject: research study reminder
----- Message Text -----

This email is to remind you that you are scheduled to participate in our research study of search systems on ***[DAYOFWEEK, MONTH, DAY starting at TIME]*** in room 12 of Manning Hall. The session should take approximately 45 minutes and you will receive $15 at the end of the session. If you need to CANCEL your session please reply to this email as soon as possible.

About the research study:
In this study, you will be asked to use a web browser and a search system to find information for two tasks that we will give to you. While you work on the tasks, we will use an eye-tracker to track where you look on the computer screen. You will also be asked to answer some questions about your experience with the task.

This research study takes approximately 45 minutes. Your session will be held in our lab on-campus in Manning Hall (next to Lenoir), room 12. You will receive $15.00 for participating.

You can contact the researchers by sending an email to ***[INSERT EMAIL ADDRESS]***.

Many Thanks,
Yu Yuan, Principal Investigators | Rob Capra, Faculty Advisor School of Information and Library Science
University of North Carolina at Chapel Hill

You will not be offered or receive any special consideration if you take part in this research; it is purely voluntary. This study ***[INSERT IRB NUMBER]*** has been reviewed by the UNC Non-Biomedical Institutional Review Board and was approved ***[##/##/####]***.

Appendix 2 Consent Form

University of North Carolina at Chapel Hill
Consent to Participate in a Research Study
Adult Participants

Consent Form Version Date: __Jan 30th, 2019_____
IRB Study # 18-2931
Principal Investigator: Yu Yuan (yyu03@live.unc.edu)
Principal Investigator Department: School of Information and Library Science
Faculty Advisor: Robert Capra (rcapra@unc.edu)

What are some general things you should know about research studies?
You are being asked to take part in a research study. To join the study is voluntary. You may choose not to participate, or you may withdraw your consent to be in the study, for any reason, without penalty.

Research studies are designed to obtain new knowledge. This new information may help people in the future. You may not receive any direct benefit from being in the research study. There also may be risks to being in research studies.

Details about this study are discussed below. It is important that you understand this information so that you can make an informed choice about being in this research study.

You will be given a copy of this consent form. You should ask the researchers named above, or staff members who may assist them, any questions you have about this study at any time.

What is the purpose of this study?
The purpose of this research study is to investigate how people engage with elements of a search system while doing information seeking tasks.

How many people will take part in this study?
There will be approximately 16 people in this research study.

How long will your part in this study last?
This study will last around 45 minutes.

What will happen if you take part in the study?

During this study, you will be asked to collect useful and thorough information for two tasks which we will give to you. During the task, a search system will be available for you to find information.

After you consent to participate in this study, we will ask you to complete an entry questionnaire to collect related background information. As you work on the tasks, we will log your interactions with the system on our server and record the computer screen you used. We will also use a Tobii X2-60 eye-tracking system to keep track of where you look on the computer screen. Before and after each task, we will ask you to complete questionnaires about your experiences with the task. After two tasks are completed, we will play back video recordings of your searches and ask you some questions about your search process at that time.

Here is the list of steps involved in this study:

1. Consent to participate.
2. Complete an Entry Questionnaire with related background information.
3. Complete a Pre-Task Questionnaire about the first task.
4. Work on the first tasks by looking for useful information to satisfy the task description.
5. Complete a Post-Task Questionnaire about the first task.
6. Repeat Steps 3-5 with second task.
7. Watch recordings of your search process for each task and answer questions about your experience during the search.
8. Receive $15 for participation.

What are the possible benefits from being in this study?
Research is designed to benefit society by gaining new knowledge. You will not benefit personally from being in this research study.

What are the possible risks or discomforts involved from being in this study?
We anticipate that no risks or discomforts are involved in this study.

How will information about you be protected?
We will not associate your name with the data, and you will not be identified in any report or publication about this study.

The data you provide to us will be stored in a secure server space (we will randomly assign the participant id number to it), and only the researchers will be given access to the data.

What if you want to stop before your part in the study is complete?
You can withdraw from this study at any time, without penalty. The investigators also have the right to stop your participation at any time. This could be because you have had an unexpected reaction, or have failed to follow instructions, or because the entire study has been stopped.

Will you receive anything for being in this study?
You will be receiving $15 for taking part in this study. If you decide to withdraw the study during the experiment, you will receive $10. If we discontinue your participation for not following instructions, you will receive nothing.

Will it cost you anything to be in this study?
It will not cost you anything to be in this study.

What if you are a UNC student?
You may choose not to be in the study or to stop being in the study before it is over at any time. This will not affect your class standing or grades at UNC-Chapel Hill. You will not be offered or receive any special consideration if you take part in this research.

What if you have questions about this study?
You have the right to ask, and have answered, any questions you may have about this research. If you have questions about the study (including payments), complaints, concerns, or if a research-related injury occurs, you should contact the researchers listed on the first page of this form.

What if you have questions about your rights as a research participant?
All research on human volunteers is reviewed by a committee that works to protect your rights and welfare. If you have questions or concerns about your rights as a research subject, or if you would like to obtain information or offer input, you may contact the Institutional Review Board at 919-966-3113 or by email to IRB_subjects@unc.edu.

Participant's Agreement:

I have read the information provided above. I have asked all the questions I have at this time. I voluntarily agree to participate in this research study.

_____ _____
Signature of Research Participant Date

_____
Printed Name of Research Participant

_____ _____
Signature of Research Team Member Obtaining Consent Date

_____
Printed Name of Research Team Member Obtaining Consent

Appendix 3 Entry Questionnaire

- Which of the following describes you best?
    - Undergraduate student
    - Graduate student
    - Doctoral candidate

- What department are you affiliated with (if any)?

- Indicate your level of agreement with the following statements.
  (*Adapted from the ISES (Tsai & Tsai, 2003)*)

    1. I usually feel lost or confused when I am seeking information on the Internet.
    2. I think I am the kind of person who can make good use of the search engine.
    3. I think I know how to construct my query to search for information on the Web.

Appendix 4 Pre-task Questionnaire

Task Description:

<<display task description here>>

Your goal will be to search and collect useful and comprehensive information for this task.

Please carefully review the task description and indicate your level of agreement with the following statements.

<<each statement will be displayed with a 5-point Likert-type agreement scale>>

1. I am interested in this topic.
2. I already know a lot about this topic.
3. I think it will be difficult to complete this task.
4. I think it will be difficult to search for information to complete this task.
5. Right now, I know what specific things to look for to complete this task.

Appendix 5 Post-task Questionnaire

Based on your search experience with the system, please indicate your level of agreement with the following statements.

<<each statement will be displayed with a 5-point Likert-type agreement scale>>

#FA1. I lost myself in this search experience.

#FA2. The time I spent searching just slipped away.

#FA3. I was absorbed in the search task.

#PU1. I felt frustrated while doing the search task.

#PU2. My search experience was taxing.

#PU3. I found the search system confusing to use.

#RW1. My search experience was worthwhile.

#RW2. My search experience was rewarding.

#RW3. I felt interested in the search task.

#SysQual1. The quality of the search results was good.

#SysQual2. The search system was helpful in supporting my search task.

Appendix 6 Retrospective Interview Questions

During the retrospective recall interview, the recordings of the participant completing each task will be replayed to the participant. For each task, the following questions will be asked after replaying the recording.

- *Do you remember seeing the InfoBox tool on this search page? Did you pay any attention to it?*

  [IF YES]

  - *At what point in the search did the InfoBox draw your attention?*
  - *Do you remember what your motivation was for looking at it?*
  - *Did you actively use it?*

    [IF YES] *Did you gain anything from looking at or using it?*

    [IF NO] *Do you remember why you choose not to use it for this task?*
- *What do you think about the content the tool provided?*

<<AFTER REPLAYING EACH OF THE TASKS, THE FOLLOWING SUMMARY QUESTIONS WILL BE ASKED>>

- *Did you notice that the InfoBox was in different locations on the screen?*
- *Was one of the locations more appealing or helpful to you? If so, why?*
- *Do you notice any difference in your use of the InfoBox in the different layouts?*
- *Did the different layout affect your task completion in any way?*
- *Did you notice that the InfoBox displayed different types of information (e.g., facts, opinions)?*
- *Were the different types of information useful in different tasks or in different ways?*
- *Which position/layout do you prefer of this search assistance tool?*

[IF USED INFOBOX]

● Which type of information in the IB was most useful for the first task? Why?

● Which types of information in the IB was most useful for the second task? Why?

Appendix 7 Search System Interface Screenshot

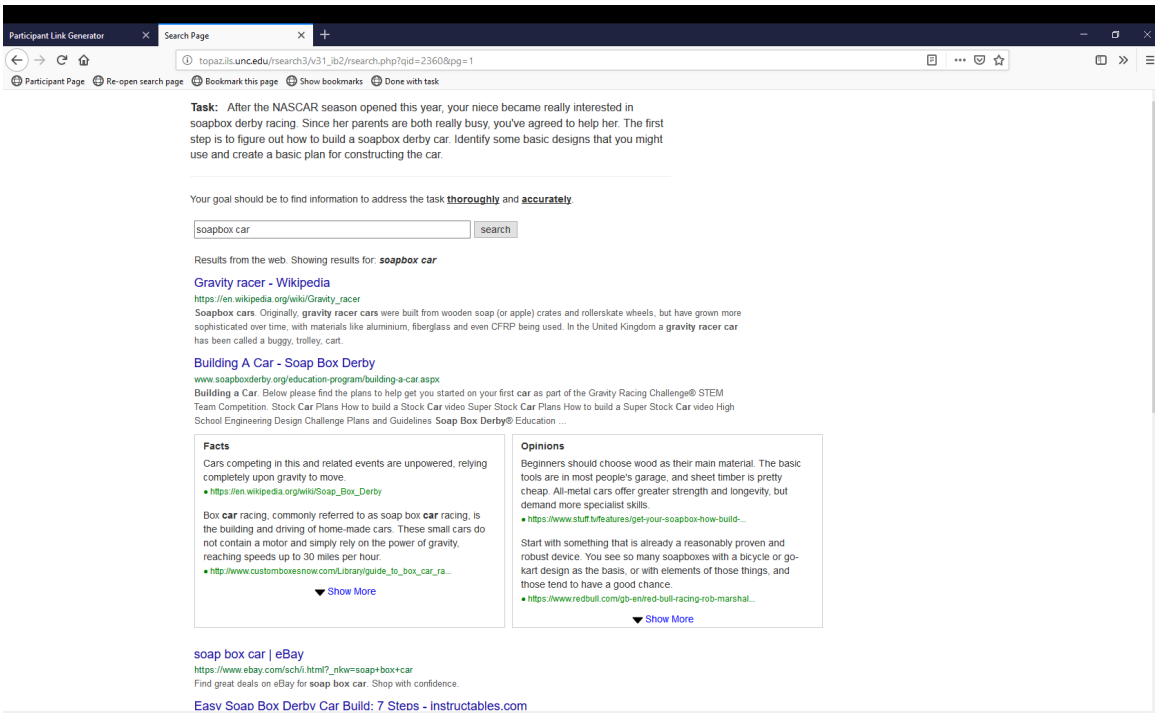

Figure 4. InfoBox Search System Search Result Page Screenshot

Appendix 8 Eye-Gaze Pattern Examples—Camouflage Link

Figure 5. Participant 10's Eye-Gaze Pattern in Soapbox Car Task—Camouflage Link

Figure 6. Participant 4's Eye-Gaze Pattern in Soapbox Car Task—Camouflage Link

Appendix 9 Eye-Gaze Pattern Examples—Banner Blindness

Figure 7. Participant 8's Eye-Gaze Pattern in Soapbox Car Task—Banner Blindness

Figure 8. Participant 10's Eye-Gaze Pattern in HIV Task—Banner Blindness